



ontario hydro research division

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research Division
Reproduced in Whole or in Part

To: Mr. D.A. Lee
Manager
Safety Services Department
Health & Safety H2 A20

A MAGNETIC FIELD PROBE FOR USE IN EXTREMELY LOW FREQUENCY (ELF) ANIMAL EXPOSURE SYSTEMS

R. Scheer

A magnetic field probe for use with an ELF animal exposure system has been developed and its performance specifications are presented in this report.

INTRODUCTION

As part of the EMFRAP program, the Research Division was commissioned to build exposure systems for generating 60 Hz magnetic fields similar to those produced by power lines. A device to measure magnetic fields in the exposure chambers was necessary to calibrate and verify the performance of the exposure units.

Other probes used for measuring magnetic fields either do not provide the required waveform accuracy, or are too large to measure localized fields at the bottom of the mouse cage.

OBJECTIVES

The design objectives to be met by this device are as follows:

- 1) The device has to be small enough to fit inside a mouse cage.
- 2) It has to reproduce an ELF waveform accurately.
- 3) The dynamic range of the device should cover fields between 1 μ T and 5 mT.
- 4) A simple relationship between field strength and output signal is desired.
- 5) Signals outside the range of interest should be filtered out.

THEORY OF OPERATION

A magnetic field probe consists of a coil of wire connected to circuitry that provides the desired response. The more turns on the coil of wire the larger the output of the coil of wire to a magnetic field. However, this type of detector is also frequency related, (this is seen in Figure 1), so output circuitry is needed to remove the frequency dependence and filter out the fields that are not of interest.

job	file	date	report no.
16-230	817.22	June 9, 1989	89-159-K

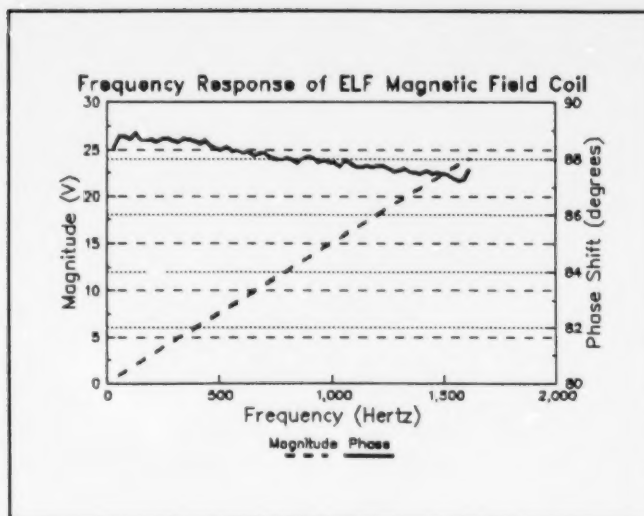
LEGAL NOTICE

This report was prepared by Ontario Hydro and, while effort has been made to assure the accuracy and applicability of the material contained herein, neither Ontario Hydro nor any person acting on its behalf:

- (a) makes any warranty, *i. pres-* or implied with respect to the use of any information, apparatus, method or process disclosed in this report or that such use may not infringe privately owned rights; or
- (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

For our purposes a coil of wire with a large number of turns, and a small size would be required. Instead of designing such a coil it was decided to test some coils removed from old electromechanical relays to find if one had the required frequency response and sensitivity. One such coil was found and its open-circuit voltage response is shown in Figure 1.

To allow for the gain to be adjusted to an easy to use value the output of the coil was to be amplified and waveshaped using an external preamplification circuit. The output of this preamplifier would be read with an oscilloscope, or other readout devices.



PERFORMANCE SPECIFICATIONS Figure 1

1) Test Methods

To test the frequency response of various coils, to the desired field strength, a solenoid of known geometry was constructed. The field produced by the solenoid versus input current was determined mathematically to be 0.239 mT/Ampere current.

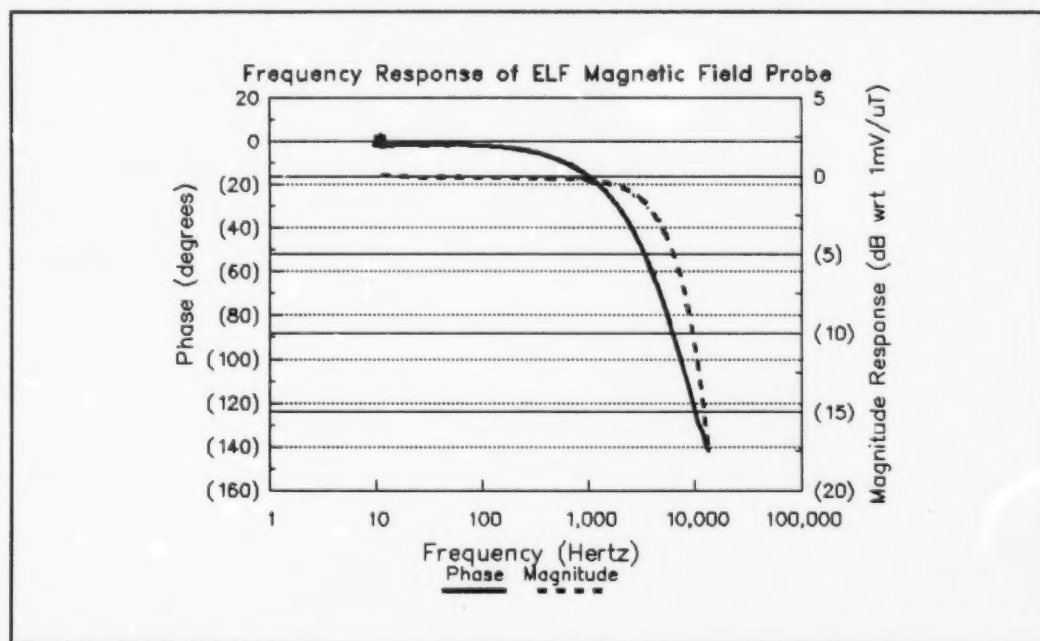


Figure 2

To measure the input current a Pearson (Model 411) Current Transformer was used. The frequency response of the coil was determined using an HP35660A Signal Analyzer, connected in such a way as to compare the output voltage to the input current. The results of this experiment are shown in Figure 1.

The coil provides a relatively large signal-to-field value. This signal was then conditioned to remove its frequency dependence and to cut off the higher frequencies.

2) Frequency Response

The experiment first described was repeated to find the frequency response of the coil and preamplifier signal; the results are in Figure 2. This frequency response allows a real time measurement of the magnetic field between 10 and 1000 Hz, this will allow the use of this detector for the measurement of waveforms with a large harmonic content. An example of this will be shown later in the report.

3) Linearity

Because of the large dynamic range required from the preamplifier a check of the systems linearity was required. To do this the system was set up as per the frequency response test, but in this case the amplitude of the magnetic field was varied instead of the frequency. The results of this experiment are shown in Figure 3.

4) Waveform Accuracy

The real time response was also measured and the response is shown in Figure 4 (from Tektronix 2430A). Pictures from a Tektronix 465 are shown in Figure 5.

The realtime test was based on a triangular waveform with a duty cycle of 10% and a frequency of 100 Hz. This was done to measure the harmonic response of the circuit.

The harmonic response is shown in Figure 6.

5) Amplitude Calibration

The device was adjusted to provide a response of $1 \text{ mV}/\mu\text{T} \pm 1\%$ from 10 to 800 Hz. This allows measurements down to $2 \mu\text{T}$ (2 mV), the noise floor of the circuit, and up to 5 mT (5 V) while providing an output which is compatible with most oscilloscopes. It should be noted that there is a dc offset in the output of the preamplifier, which can be ignored for ac field measurements.

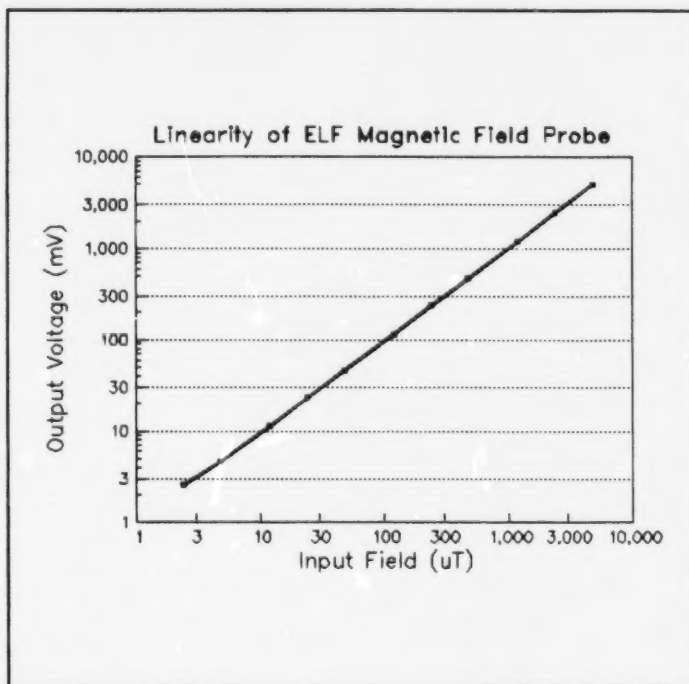


Figure 3

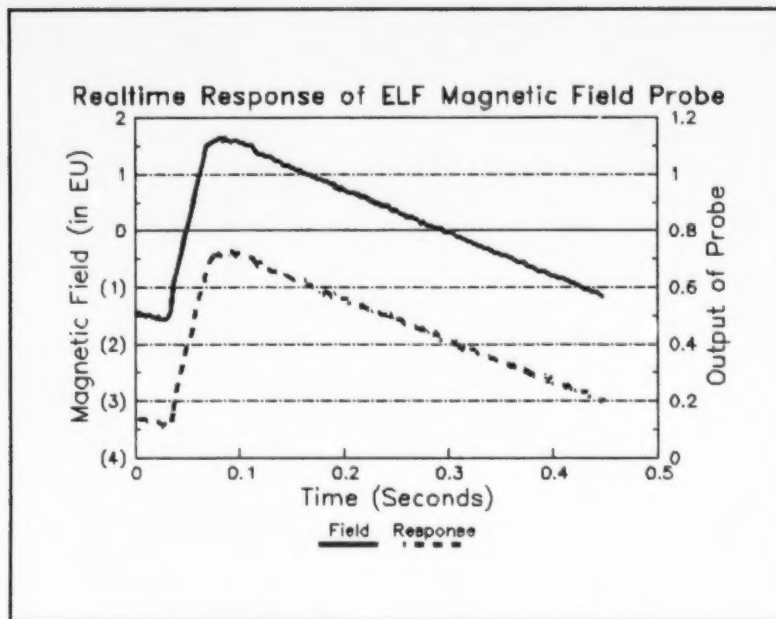


Figure 4 - A Comparison of the Input Current Waveform and the Magnetic Field Probe output using a Tektronix 2430 Oscilloscope



Figure 5 - A Comparison of the Input Current Waveform versus the Magnetic Field Probe output using a Tektronix 465 Oscilloscope. The upper waveform is the output of the Field Probe. The lower waveform is the current in the solenoid. The timebase is 2 ms/div

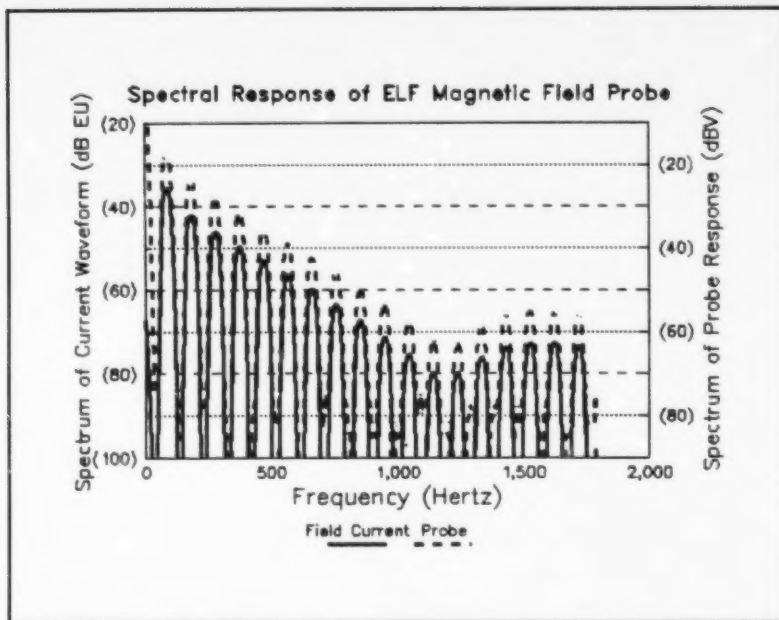


Figure 6 - A comparison of the Input Current Waveform Spectrum with the Magnetic Field Probe output using a Hewlett Packard 35660A Spectrum Analyzer.

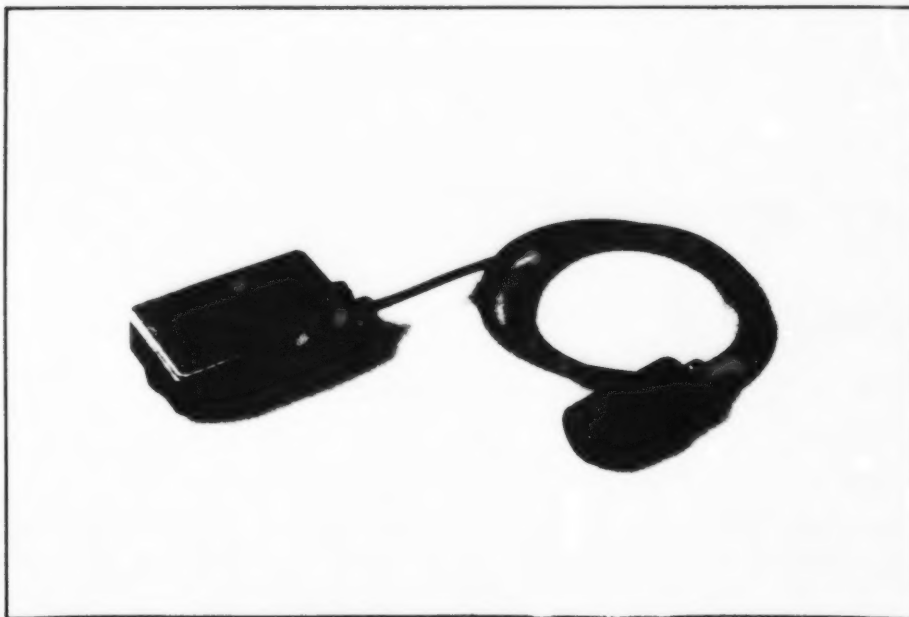


Figure 7 - A picture of the Magnetic Field Probe and preamplifier.

CONCLUSIONS

A probe has been built which has a usable frequency bandwidth of 60 Hz to 1 kHz, and a dynamic range of 2 μ T to 5 mT. It meets all the requirements for testing the field levels inside the exposure chambers, and can be used with low cost oscilloscopes.

Approved:

Submitted:

A. F. Baljet

Russell

Scheer

A.F. Baljet
Manager
Electrical Research Department

Russell Scheer
Technologist
Science Section

RS:RS:CB